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Navare et al.

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(54) **SYSTEM AND METHOD FOR  
VIRTUALIZING AND CONTROLLING INPUT  
AND OUTPUT OF COMPUTER PROGRAMS**

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(\*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 8 days.

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(52) U.S. Cl. .... **709/250; 709/227**

(58) Field of Search ..... **709/250, 105, 709/238, 302, 229, 203, 245, 333, 328, 310, 1, 100, 316, 317, 319, 329, 400, 227**

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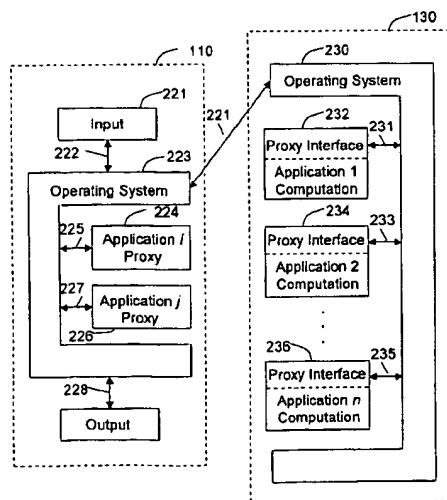
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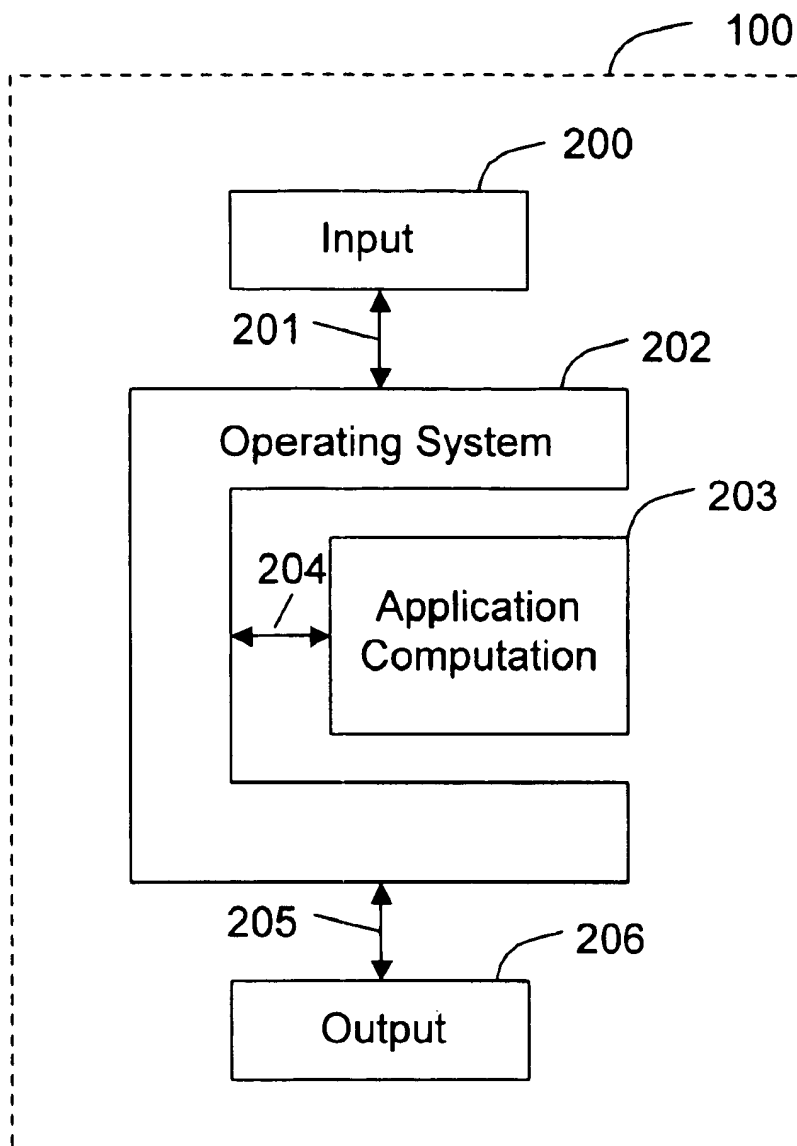
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(57) **ABSTRACT**

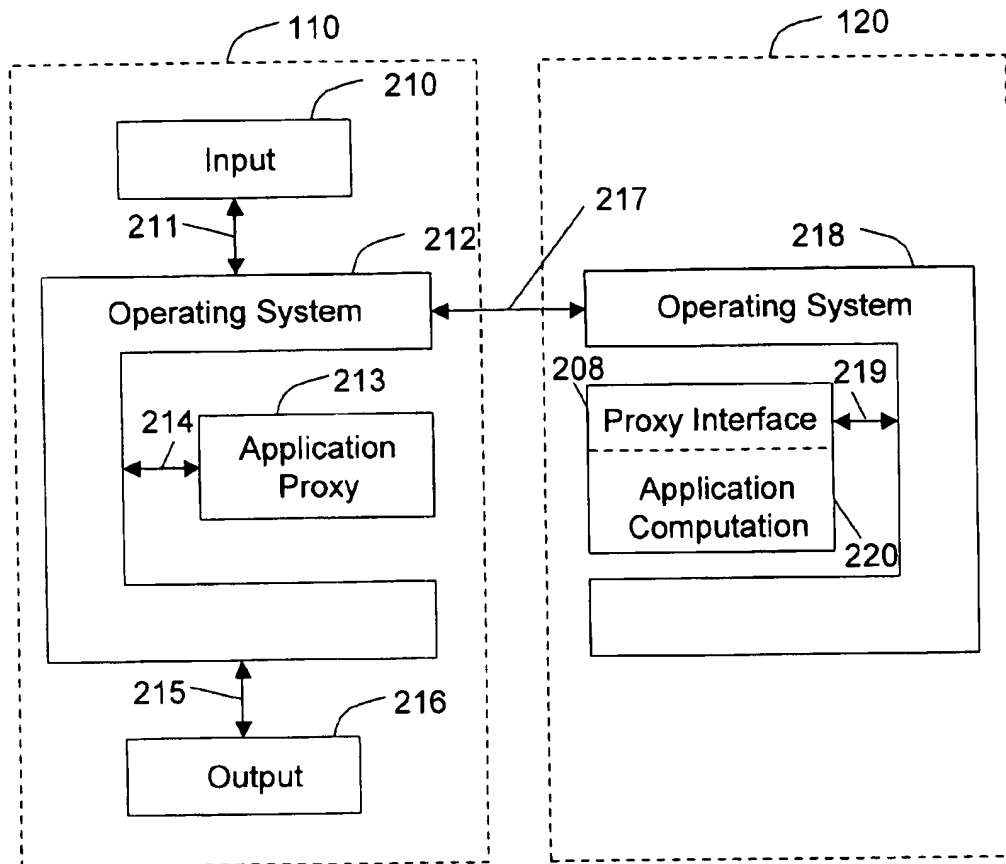
Networked processors provide application and operating system in one machine, application proxy and operating system on other machine, and virtualized input or output coupling to operating system of the other machine. Client responds to applied input and executes application proxy to apply output, while server executes application, and proxy interface sends applied input to server so server executes application per applied input and generates applied output. Proxy interface sends generated output for virtual display by client.

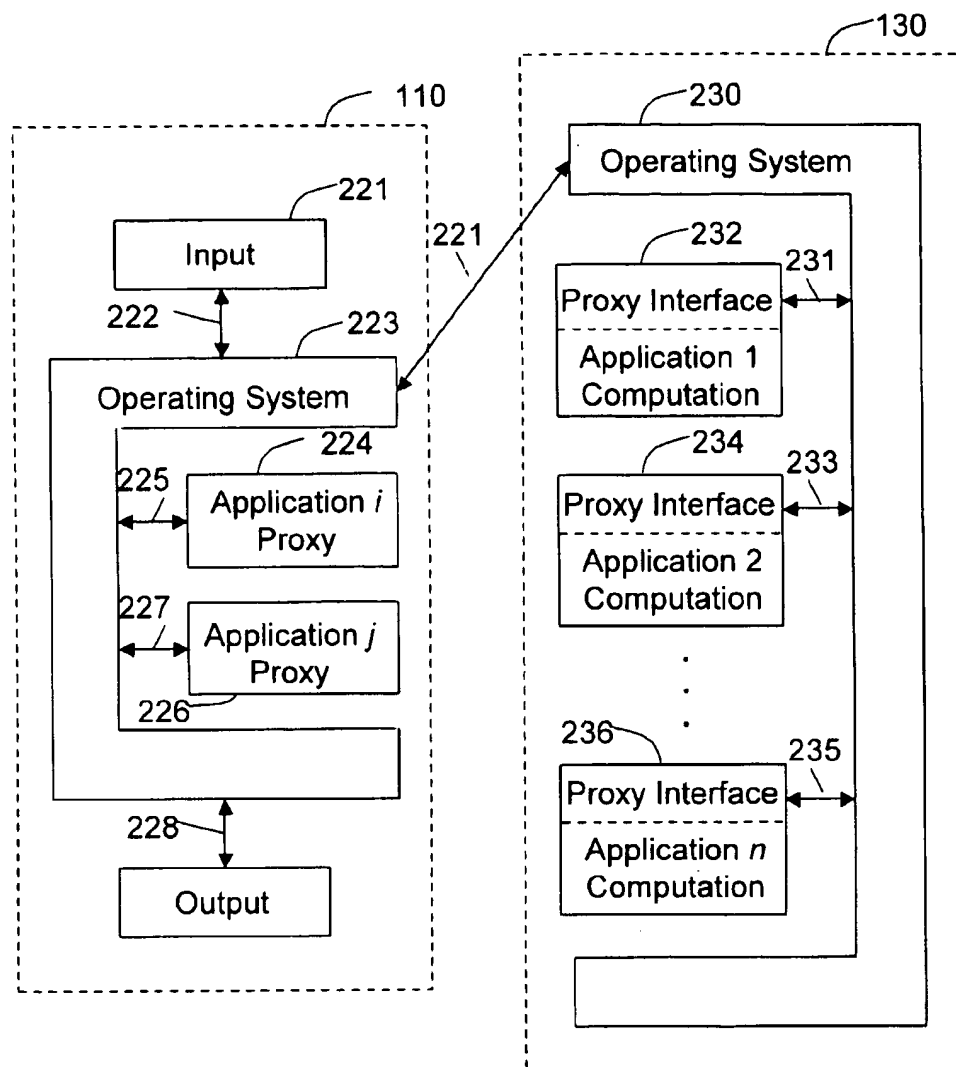
**9 Claims, 10 Drawing Sheets**

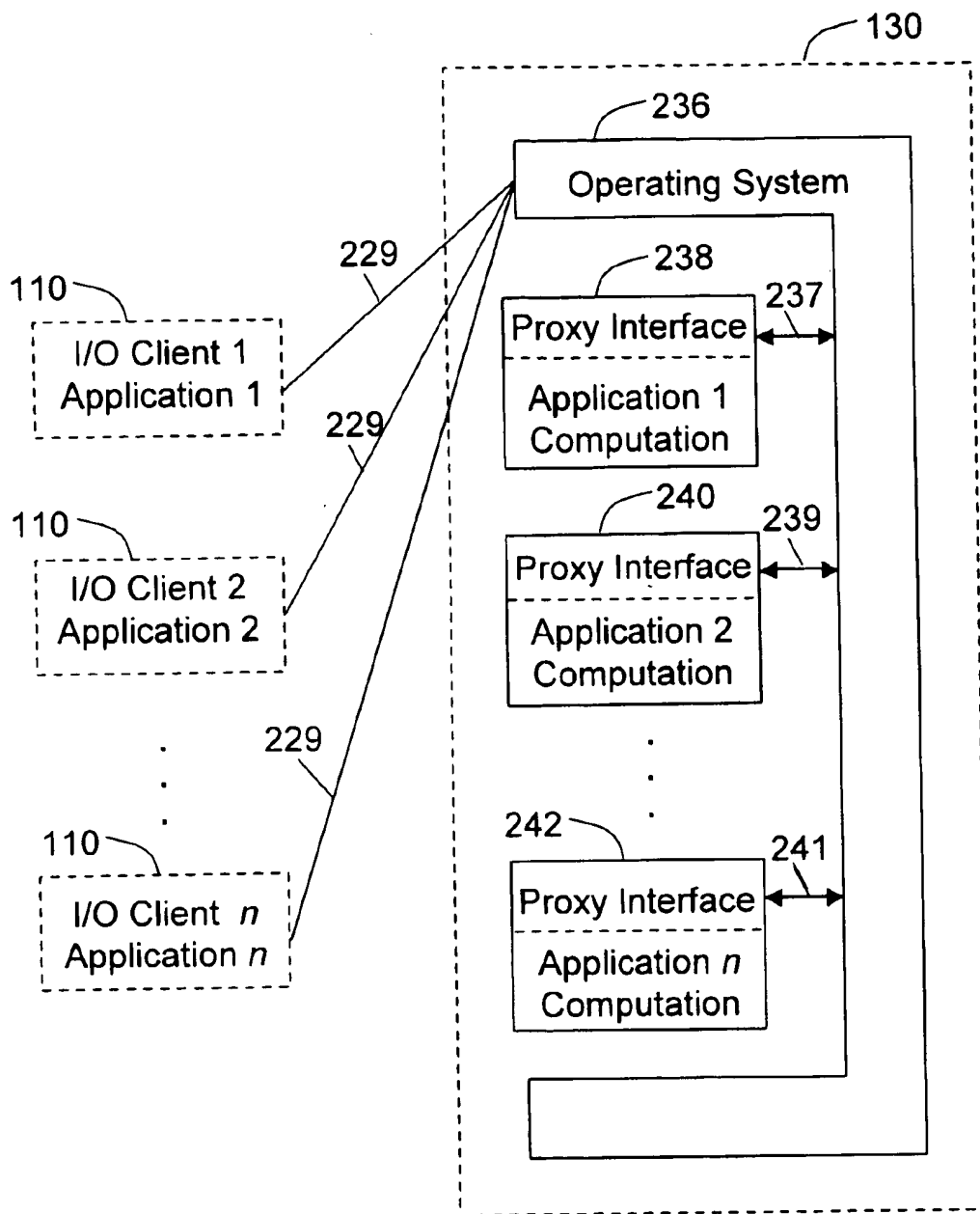


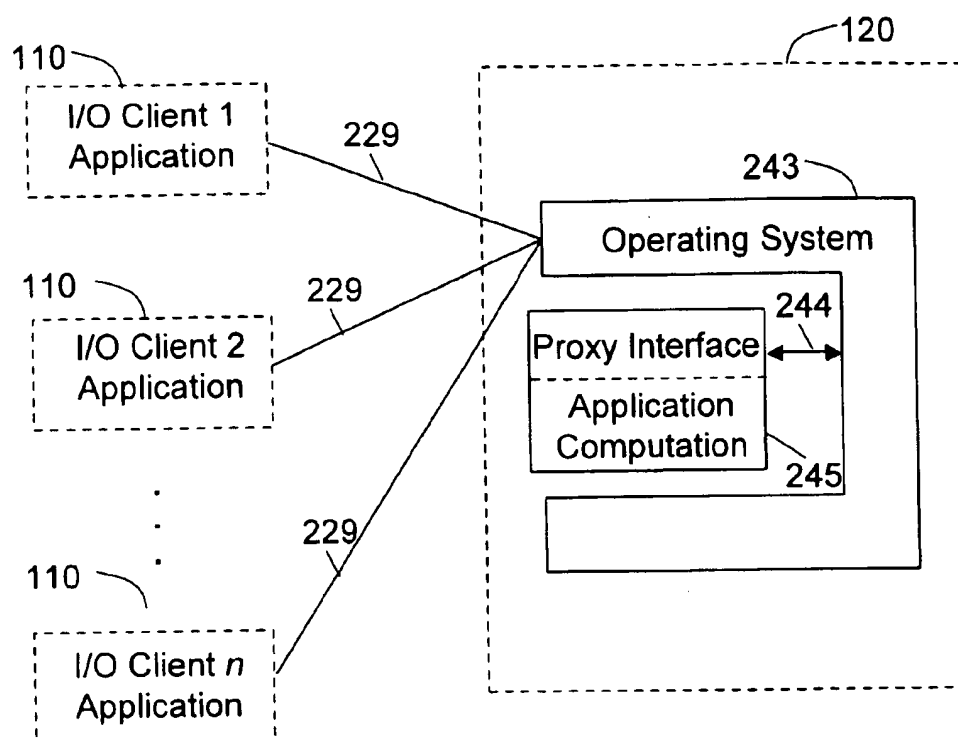


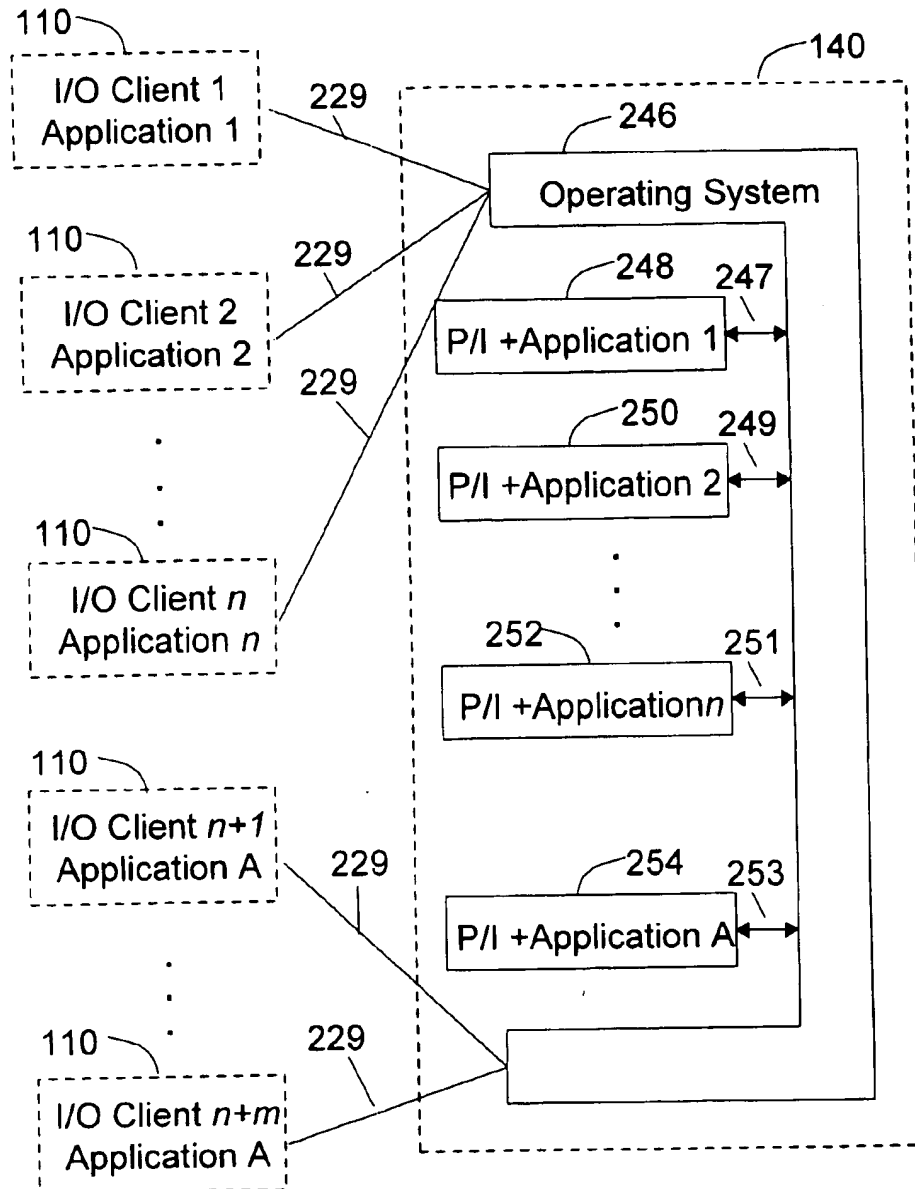
**FIG. 1**  
**PRIOR ART**

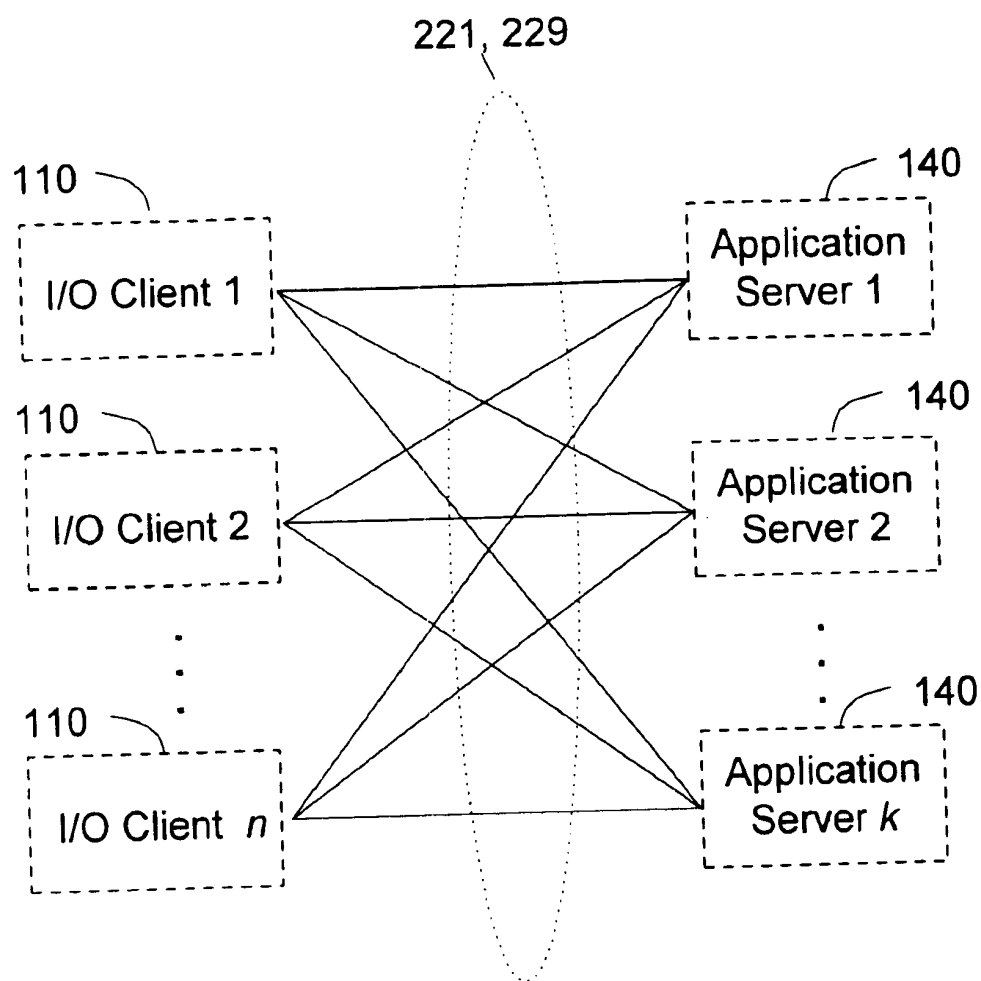
**FIG. 2**

**FIG. 3**

**FIG. 4**

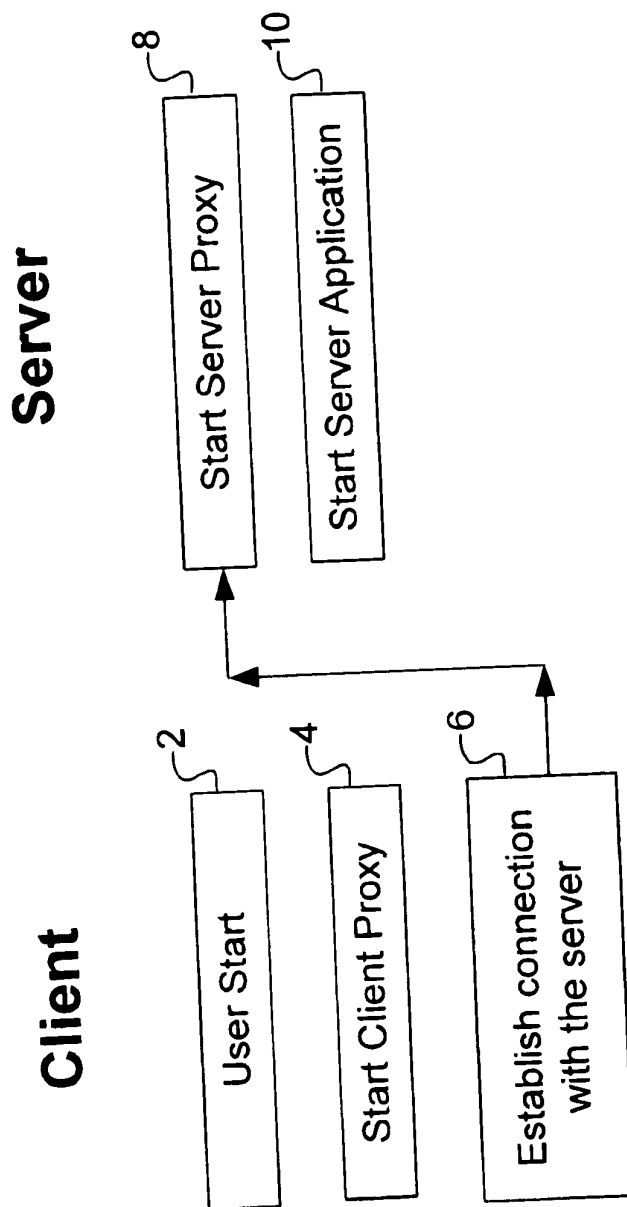
**FIG. 5**

**FIG. 6**

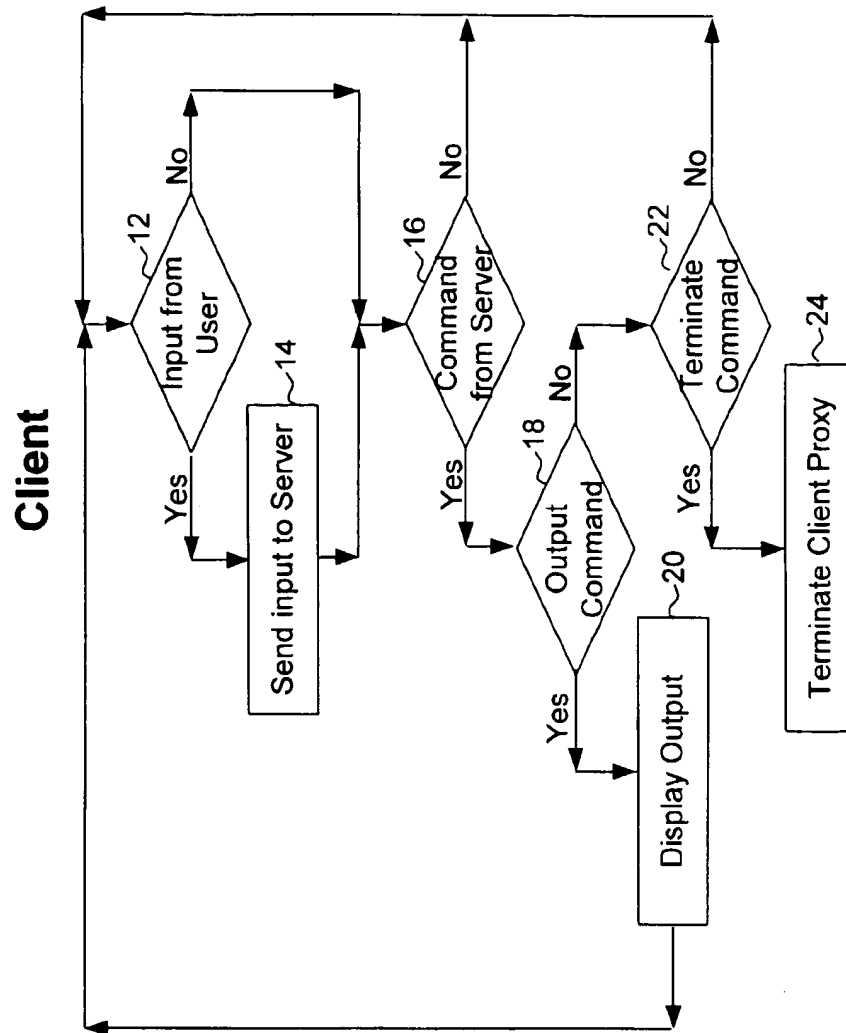
**FIG. 7**

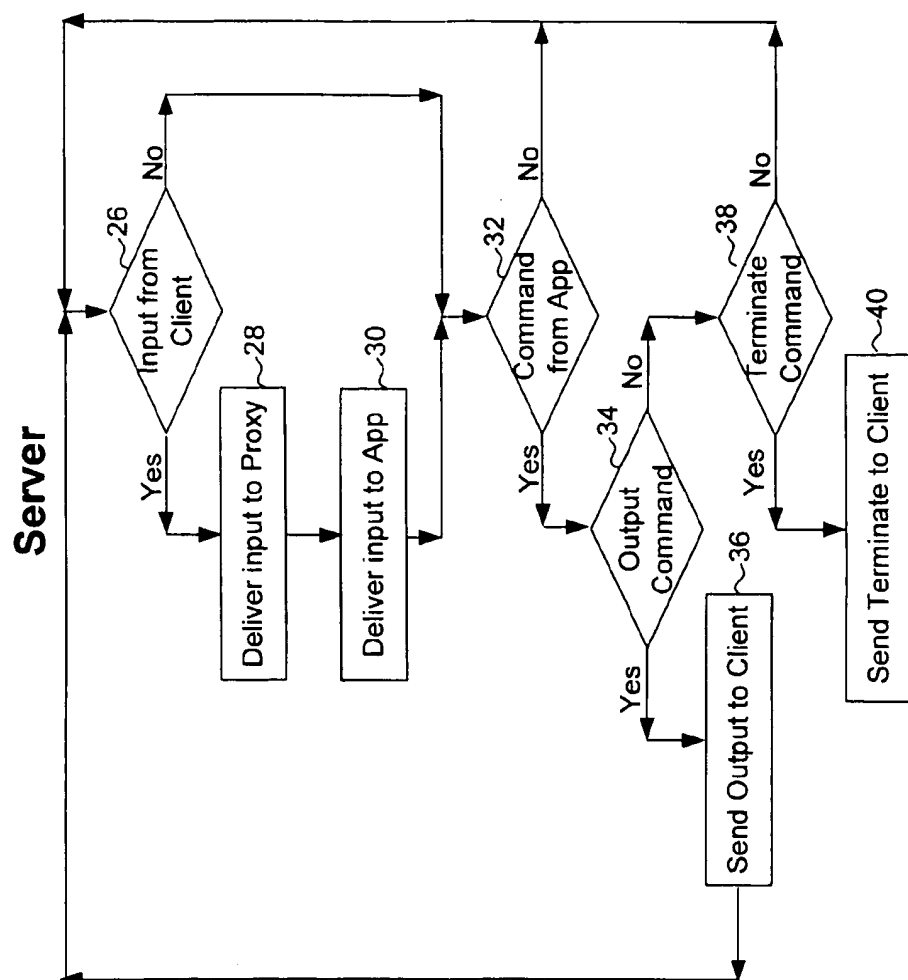


# Application Startup



**FIG. 8**

**FIG. 9**

**FIG. 10**

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# SYSTEM AND METHOD FOR VIRTUALIZING AND CONTROLLING INPUT AND OUTPUT OF COMPUTER PROGRAMS

## FIELD OF INVENTION

The invention relates to computer system user interface, particularly to virtualization and control of input and output of computer programs.

## BACKGROUND OF INVENTION

Conventional computer systems provide peripheral devices and drivers for, input (e.g., keyboard, mouse, microphone, etc.) and output (e.g., display, speaker, etc.) Ordinarily, application programs which run on such computer systems execute assuming that I/O devices and drivers couple physically to same processing machine where such application(s) run. In certain cases, however, such as networked multi-computer systems, it would be desirable to provide that computer application and I/O not reside on identical system. Prior related techniques are described, for example, in U.S. Pat. Nos. 4,454,593, 4,642,790, 4,858,114, and 5,502,839. Such references, however, are variously limited, particularly with respect to achieving optimized network flexibility and performance. Accordingly, there is a need for improved method and apparatus for controlling and virtualizing program I/O in network computing systems.

## SUMMARY OF INVENTION

The invention resides in computing system and methodology for controlling and virtualizing input and output of computer programs. Networked processors provide application, proxy interface and operating system in one machine, application proxy and operating system on other machine, and virtualized input or output coupling effectively therebetween.

In particular, one or more client processors respond to input applied respectively thereto and execute one or more application proxies to apply outputs respectively. Meanwhile, one or more server processors execute one or more applications, wherein one or more proxy interfaces send respective applied input to certain server processors so that such server processors execute certain applications per applied input and generate applied output respectively. Proxy interfaces send generated output for virtual display by certain client processors.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a block diagram of conventional computer system (PRIOR ART).

FIG. 2 is a block diagram of computer system according to present invention.

FIGS. 3-7 are block diagrams of computer systems according to alternative embodiments of present invention.

FIG. 8 is a generalized flow chart of processing steps by client and server according to present invention.

FIG. 9 is a more detailed flow chart of processing steps by client processor according to present invention.

FIG. 10 is a more detailed flow chart of processing steps by server processor according to present invention.

## DETAILED DESCRIPTION

FIG. 1 shows conventional computer system and software 100 including application program 203 installed 204 with operating system (OS) 202, and input driver and/or device 200 coupled 201 thereto and output device and/or driver 206 coupled 205 thereto. Typically, system 100 is provided on

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conventional hardware equipment including processor, storage and other computer peripherals.

FIG. 2 shows networked computer system diagram according to present invention, including client processor portion (client) 110 and server processor portion (server) 120 coupled 217 thereto, preferably using conventional network interconnect protocol stack. Client 110 includes application proxy 213 installed 214 with operating system 212, and input driver and/or device 210 coupled 211 thereto and output device and/or driver 216 coupled 215 thereto. Client 110 may be provided on conventional hardware equipment including processor, storage and other computer peripherals.

Server 120 includes proxy interface 208 and application 220 installed 219 with operating system 218. Server 120 may be provided on conventional hardware equipment including processor, storage and other computer peripherals.

As used herein, term "application proxy" is understood to mean any computer program intended to include one or more instructions corresponding to another application program, such that when the application proxy serves to copy, simulate or emulate functionally, at least in part, the other application program when executed. further, as used herein, term "proxy interface" is understood to mean any computer program intended to cooperate functionally with the application proxy and couple with or monitor the application program associated with the application proxy.

In accordance with an important aspect of present invention, computer program input and output are controllable and/or virtualizable in a networked client/server computer system configuration. Generally, in a multi-processor network for distributed computing, wherein one or more application programs are provided to run primarily on a particular processor (e.g., server), particularly where execution of such application program(s) is configured for or contemplates usage of computer input, output and/or other media functional facilities (such as input: keyboard, mouse, microphone, etc., and output: display screen, speaker, etc.) resident locally or associated functionally with such server processor, one or more other processor (e.g., clients) coupled to such server processor effectively executes or appears to execute substantially the same application program executed by the server processor.

Preferably, distributed network processing is achieved by applying a proxy interface to the application program in the server processor, such that a corresponding application proxy program is executable by one or more client processors coupled thereto. In this partitioned computing scheme, control of, interconnection with, or access, to input, output or other observable or detectable media instructions, commands, messages, primitives, data streams, signals, or other functionally comparable digital information flow is effectively redirected, substantially filtered, or functionally switched by software and/or equivalent or associated hardware functionality as described as herein, such as including application proxy 213 and proxy interface 219, from being coupled, channeled or monitored by any I/O function or associated media facilities locally resident or functionally peripheral to server processor 120 to substantially equivalent I/O function or associated media facilities locally resident or functionally peripheral to one or more client processor 110.

Hence, in this virtualized I/O manner, one or more application programs 220 may run on one processor system 120, and function as though input, output and/or other observable or detectable media signal information for executing such application programs are available and accessed locally to such system 120, without any substantial modification, interruption or other operational change to such programs 220, but actually or effectively cooperate with one or more other processor system 110 coupled 217 thereto through

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corresponding application proxy 213 and proxy interface 208 means, such that subject application program I/O and other related or selected I/O processing activity, instructions, messages, primitives, commands, data streams, signals, or other functionally comparable digital information flow are directed, sent or transferred to and/or from I/O facilities 210, 216 available and accessed locally to other processor system 110.

Preferably, when operating, client processor 110 responds to input 210 applied 211 respectively thereto and executes application proxy 213 to generate or apply 215 output 216, so that such client processor 110 effectively appears to execute full application program 220 locally, although subset or partitioned portion of instruction set is provided thereto for local execution. In addition, server processor 120 executes application 220, and proxy interface 208, which coupled thereto, sends input 210 from client processor 110 to server processor 120 so that server processor 120 executes application program 220 according to such applied input and generates therefrom output, which is applied by proxy interface as output 216 of client processor 110. In effect, proxy interface 208, in functional cooperation with application proxy 213, serves to deliver virtual display of output 215 by client processor 110 and collect actual input therefrom for delivery to server processor 120.

FIG. 3 shows alternate computer system with client unit 110 and server unit 130. Substantially similar to system of FIG. 2, client 110 includes operating system 223 coupled 222, 228 respectively to input 221 and output 228 for virtualized I/O operation as described herein, and server 130 includes operating system 230. In particular, client 110 includes multiple application i . . . j proxies 224, 226 coupled 225, 227 respectively to operating system 223, and server 130 includes multiple application programs and proxy interfaces 232, 234, 236 correspondingly coupled 231, 233, 235 to operating system 230. In this alternate configuration, multiple virtualized I/O data flows using single client/server coupling 221 are contemplated, such that each application proxy communicates with corresponding proxy interface, thereby eliminating data conflict therebetween.

FIG. 4 shows other alternate computer system with multiple client units 110 coupled over multiple link or data flows 229 to server unit 130. Substantially similar to system of FIG. 3, each client 110 includes operating system coupled to input and output for virtualized I/O operation as described herein, and server 130 includes operating system 236. In particular, client 110 includes multiple I/O client applications 110, and server 130 includes multiple application programs and proxy interfaces 238, 240, 242 correspondingly coupled 237, 239, 241 to operating system 236. In this other alternate configuration, multiple data flows use multiple client/server couplings 229 are contemplated, such that each application proxy from multiple client units communicate with corresponding proxy interface at single server unit.

FIG. 5 shows another alternate computer system with multiple client units 110 coupled over multiple link or data flows 229 to server unit 120. Substantially similar to system of FIG. 4, each client 110 includes operating system coupled to input and output for virtualized I/O operation as described herein, and server 120 includes operating system 243 and application program with proxy interface 245 coupled 244 thereto.

In such configuration, I/O streams 229 from multiple clients 110 are provided to server 110, wherein same application program 245 and associated data and states are provided. Hence, such configuration may support centralized client/server applications, where multiple clients communicate with single server under control of particular application or database, such as data warehousing, group

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conferencing, distance learning, collaboration, bulletin boards, kiosk, vote polling, etc.

FIG. 6 shows alternative computer system with multiple client units 110 coupled over multiple link or data flows 229 to server unit 140. Substantially similar to system of FIG. 5, each client 110 includes operating system coupled to input and output for virtualized I/O operation as described herein, and server 140 includes operating system 246; however, multiple application programs with proxy interfaces 248, 250, 252, 254 are coupled correspondingly 247, 249, 251, 253 thereto. In such alternative configuration, I/O streams 229 from multiple clients 110 are provided to server 110, wherein multiple application programs and proxy interfaces are provided for access thereto. Such alternative configuration may support centralized, distributed, shared, or other multiple client/server applications.

FIG. 7 shows other alternative computer system with multiple client units. 110 coupled over multiple shared or dedicated link or data flows 221, 229 to multiple server units 140. Substantially similar to system of FIG. 6, each client 110 includes operating system coupled to input and output for virtualized I/O operation as described herein, and each server 140 includes operating system and application program with proxy interface. In such other alternative configuration, I/O streams 221, 229 from multiple clients 110 are provided to multiple server 110, wherein multiple application programs and proxy interfaces are provided for access thereto. Such other alternative configuration may support load-balancing or fault-tolerant client/server applications.

FIG. 8 illustrates processing steps performed in series and/or parallel by client and server processing units. Initially 2, user starts client processor, and then starts client application proxy program 4. Next, physical or network connection is made 6 with server processing unit, preferably according to conventional network interconnect protocol stack. After network connection is established on server side, server proxy interface program has been started 8, and server application program also started 10.

FIG. 9 shows client operational steps which occur preferably after client proxy, starts 4. Firstly, client processor determines whether input activity, instructions, messages, primitives, commands, data streams, signals, or other functionally comparable digital information flow (i.e., input) is received 12 from user; if so, then such input is sent 14 to server processor. Then, client processor determines whether any command is received 16 from server. If so, then client processor further determines whether such received command is for output if so, then such output is displayed 20. Otherwise, if client processor determines that such received command, which is not for output, is terminate indication, then client proxy program is terminated 24. Else, client process flow is repeated as shown.

FIG. 10 shows server operational steps which occur preferably after server proxy interface program starts 8. Firstly, server processor determines whether input is received from client 26; if so, then such input is sent 28 to server proxy interface, which further delivers 30 such input to application program. Then, server processor determines 32 whether application generates command; if so, then server processor determines 34 whether such received command is for output as activity, instructions, messages, primitives, commands, data streams, signals, or other functionally comparable digital information flow (i.e., output). If so, then such command output is sent 36 to client. Otherwise, if server processor determines 38 that such received command, which is not for output, is termination, then terminate indication is sent 40 to client. Else, server process flow is repeated as shown.

The foregoing described embodiments of the invention are provided as an illustration and description. It is not

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intended to limit the invention to the precise form described. Other variations and embodiments are possible in light of the above teaching, and it is thus intended that the scope of the invention not be limited by the detailed description, but rather by the claims as follow.

We claim:

1. A network computing system comprising:

a first processing unit comprising a first processor, a first storage, a first input device, a first output device, a first operating system and a plurality of application proxies, the first operating system being provided in the first storage for execution by the first processor; and

a second processing unit comprising a second processor, a second storage, a second input device, a second output device, a second operating system, a plurality of applications, and a plurality of proxy interfaces, the second operating system being provided in the second storage for execution by the second processor;

wherein the first processing unit couples through a network connection to the second processing unit for distributed processing of the plurality of applications therebetween, the plurality of applications being executable by the second processor, the plurality of application proxies being executable by the first processor, each application proxy from the plurality of application proxies being coupled effectively to a corresponding proxy interface from the plurality of proxy interfaces, such that when the second processor executes an application from the plurality of applications, said corresponding proxy interface from the plurality of proxy interfaces causes an input signal from the first input device, instead of the second input device, to be virtualized to the second processor executing the application from the plurality of applications, and an output signal generated by the second processor executing the application from the plurality of applications to be virtualized to the first output device, instead of the second output device, wherein the first processing unit and the second processing unit continually virtualizes the inputs and outputs at each subsequent input from the first processing, such that the input from the first processor continually alter the processing in the second processing unit; and

wherein one or more application proxies serve to copy, simulate or emulate functionally, at least in part, its corresponding application program when executed, and one or more proxy interfaces cooperate functionally with its corresponding application proxy to monitor the application program corresponding to the application proxy.

2. A client/server computing system for virtualized input/output comprising:

a client processor, in response to a first input applied thereto, executing a first applicator proxy and applying a first output; and in response to a second input applied thereto, executing a second application proxy and applying a second output;

a server processor for executing a first application, a first proxy interface being coupled to the first application for sending the applied first input to the server processor, such that the server processor executes the first application in response to such applied first input and generates therefrom the applied first output, the first proxy interface sending such generated first output for application to the client processor and for executing a second application, a second proxy interface being coupled to the second application for sending the

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applied second input to the server processor, such that the server processor executes the second application in response to such applied second input and generates therefrom the applied second output, the second proxy interface sending such generated second output for application to the client processor;

wherein the client processor and the server processor continually virtualizes the inputs and outputs at each subsequent input from the first processing, such that the input from the first processing unit continually alters the processing in the second processing unit; wherein one or more application proxies serve to copy, simulate or emulate functionally, at least in part, its corresponding application program when executed, and one or more proxy interfaces cooperate functionally with its corresponding application proxy to monitor the application program corresponding to the application proxy.

3. The system of claim 2 further comprising:

an other client processor, in response to a first other input applied thereto, executing a first other application proxy and applying a first other output;

wherein the server processor executes the first application, the first other proxy interface being coupled to the first application for sending the applied first other input to the server processor, such that the server processor executes the first application in response to such applied first other input and generates therefrom the applied first other output, the first other proxy interface sending such generated first other output for application to the other client processor.

4. The system of claim 3

wherein the other client processor, in response to a second other input applied thereto, executes a second other application proxy and applies a second other output; and

wherein the server processor executes the second application, the second other proxy interface being coupled to the second application for sending the applied second other input to the server processor, such that the server processor executes the second application in response to such applied second other input and generates therefrom the applied second other output, the second other proxy interface sending such generated second other output for application to the other client processor.

5. The system of claim 2 further comprising:

an other server processor,

for executing a first other application, a first other proxy interface being coupled to the first other application for sending the applied first input to the other server processor, such that the other server processor executes the first other application in response to such applied first input and generates therefrom the applied first other output, the first other proxy interface sending such generated first other output for application to the client processor; and

for executing a second other application, a second other proxy interface being coupled to the second other application for sending the applied second input to the other server processor, such that the other server processor executes the second other application in response to such applied second input and generates therefrom the applied other second output, the second other proxy interface sending such generated second other output for application to the client processor.

6. The system of claim 4 further comprising:

an other server processor,

for executing a first other application, a first other proxy interface being coupled to the first other application for

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sending the applied first input to the other server processor, such that the other server processor executes the first other application in response to such applied first input and generates therefrom an applied first other output;

for executing a second other application, a second other proxy interface being coupled to the second other application for sending the applied second input to the other server processor, such that the other server processor executes the second other application in response to such applied second input and generates therefrom an applied second other output;

for executing the first other application, the first other proxy interface being coupled to the first other application for sending the applied first other input to the other server processor, such that the other server processor executes the first other application in response to such applied first other input and generates therefrom the applied first other output; and

for executing the second other application, the second other proxy interface being coupled to the second other application for sending the applied second other input to the other server processor, such that the other server processor executes the second other application in response to such applied second other input and generates therefrom the applied other second output.

7. In a networked computing system comprising a client processor coupled to a server processor, a method for virtualizing input and output comprising the steps of:

a client processor executing a plurality of application proxies, wherein one or more application proxies serve to copy, simulate or emulate functionally, at least in part, its corresponding application program when executed;

the client processor establishing a plurality of connections to a server processor;

the server processor executing a plurality of proxy interfaces, wherein one or more proxy interfaces cooperate functionally with its corresponding application proxy to monitor the application program corresponding to the application proxy;

the server processor executing a plurality of applications;

a plurality of output generated by the server processor when executing the plurality of applications being provided to the client processor for virtual processing therefrom; and

a plurality of input applied to the server processor when executing the plurality of applications being provided from the client processor for virtual processing therefrom;

wherein each input of the plurality of input is associated with a corresponding application proxy of the plurality of application proxies, a corresponding proxy interface of the plurality of proxy interfaces, a corresponding connection of the plurality of connections, a corresponding application of the plurality of applications, and a corresponding output of the plurality of output; and

wherein the plurality of input and output is continually virtualized at each subsequent input from the first processing, such that the input from the first processing unit continually alters the processing in the second processing unit.

8. In a computing system coupled to a network, a method for virtualizing a plurality of signal output comprising the steps of:

executing by a client computer a plurality of application proxies;

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establishing by the client computer a plurality of connections to a server computer by a network;

receiving by the client computer a plurality of signals from the network;

determining by the client computer whether the plurality of signals comprise a plurality of media signals; and

processing by the client computer according to the plurality of application proxies the plurality of media signals to generate a plurality of virtual output;

wherein each signal of the plurality of signals is associated with a corresponding media signal of the plurality of media signals, a corresponding application proxy of the plurality of application proxies, a corresponding connection of the plurality of connections, a corresponding proxy interface of the plurality of proxy interfaces, and a corresponding virtual output of the plurality of virtual output;

wherein one or more application proxies serve to copy, simulate or emulate functionally, at least in part, its corresponding application program when executed, and one or more proxy interfaces cooperate functionally with its corresponding application proxy to monitor the application program corresponding to the application proxy; and

wherein the plurality of input and output is continually virtualized at each subsequent input from the first processing, such that the input from the first processing unit continually alters the processing in the second processing unit.

9. In a computing system coupled to a network, a method for virtualizing a plurality of signal input comprising the steps of:

executing by a client computer coupled to a network a plurality of application proxies;

executing by a server computer coupled to the network a plurality of proxy interfaces and a plurality of applications;

receiving by the server computer a plurality of signals from the client computer using the network;

determining by the server computer whether the plurality of signals comprise a plurality of media signals; and processing by the server computer according to the plurality of proxy interfaces and the plurality of applications the plurality of media signals to use the plurality of media signals as a plurality of virtual input;

wherein each virtual input of the plurality of virtual input is associated with a corresponding application of the plurality of applications, a corresponding proxy interface of the plurality of proxy interfaces, a corresponding signal of the plurality of signals, and a media signal of the plurality of media signals;

wherein one or more application proxies serve to copy, simulate or emulate functionally, at least in part, to its corresponding application program, and one or more proxy interfaces cooperate functionally with its corresponding application proxy to monitor the application program corresponding to the application proxy; and

wherein the plurality of input and output is continually virtualized at each subsequent input from the first processing, such that the input from the first processing unit continually alters the processing in the second processing unit.

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